ISLAMIC ART AND MATHEMATICS

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WHY IS THIS TOPIC IMPORTANT?

According to Steinhauer & Gallagher-Mackey (2017), it is **important for students to learn that math is not a European concept**, as well as for teachers to engage students in "culturally based inquiry math projects so that [students] can understand the breadth of this topic" (p. 38). It is our aim not only to support teachers in incorporating Islamic art and mathematics into their programs, but also to **transform the lens through which we approach Islamic culture in educational contexts.** Through our activities, we invite students and teachers to challenge their thinking in regard to what Islam has to offer, as well as what it has historically offered. Valuable learning exists in deconstructing the pattern work found in Islamic art, as well as in discovering how artists and mathematicians were able to create such intricate designs at a time when sophisticated mathematical instruments did not exist. In Islamic art and design, **mathematical concepts are transformed into artistic realities** (MMOA, 2012), and this very concept constitutes the foundation for rich learning in math and beyond.

MATH WITHIN THE ISLAMIC CONTEXT

WHY GEOMETRY?

One of the defining characteristics of Islamic art is its abundant use of shapes and geometric patterns to produce a variety of intricate designs (MMOA, 2012). These geometric designs have been used to decorate various architectural and decorative surfaces, informed in part by the traditions of the pre-Islamic Byzantine and Sasanian empires (MMOA, 2012). It is believed that the prominence of shapes and abstract geometric patterns in Islamic art stems from the fact that Muslim artists sought to avoid the representation of figural forms (i.e., people) in religious and public art (MMOA, 2012).

THE COMPASS & THE RULER

The mathematical elegance of Islamic geometric designs results not from how intricate and complex the designs can be, but from the fact that they were always constructed using a compass and a ruler (MMOA, 2012; Broug, 2015). These basic instruments were used to generate the circle and the line, upon which all Islamic geometric designs were based. The circle and the line allowed artists to create infinite variations of patterns and motifs by repeating a single geometric unit (i.e., basic shapes like circles and polygons), laid out according to a basic organizing principle (e.g., a specific spatial arrangement) (MMOA, 2012). The result is a range of complex geometric patterns that are all rooted in mathematical understandings.

SYMMETRY, REPEATING PATTERNS, & TESSELLATIONS

The majority of the patterns found in Islamic art and architecture are derived from a grid of polygons, including (but not limited to) equilateral triangles, squares, and/or hexagons. In mathematics, these grids are referred to as "'regular tessellation[s]' (deriving from the Latin terrerae, i.e., pieces of mosaic), in which one regular polygon iis repeated to tile the plane" (MMOA, 2012, p. 79). Most of the geometric patterns found in Islamic ornamentation are based on the premise that every pattern can be repeated and extended infinitely. However, no matter how complex or intricate a design is, it is still based on a regular grid (MMOA, 2012). Symmetry is created in Islamic geometric design through repetition, as well as through the mirroring of one or more basic design units (e.g., shapes such as circles and polygons) (MMOA, 2012). Although the design can always be elaborated upon and made more complex, "the basic symmetrical repetition and mirroring of these shapes creates a sense of harmony" (MMOA, 2012).

ACTIVITY 1 Minds-On: Can You Find the Math?

In asking asks students **to find the math in various Islamic and Islamic-influenced designs** (e.g., tiles, carpets, arches, muqarnas, dishware, this activity prompts thinking about mathematics in relation to Islamic art and architecture with a focus on geometry and patterning. The diverse range of images will support students not only in identifying shapes, patterns, and angles, but also in developing a broader perspective on Islamic contributions to design, art, and mathematics. This resource can be found at http://wordpress.oise.utoronto.ca/roberston/inquiry/.

ACTIVITY 2

Hands-On: Creating an Islamic Tessellation

(adapted from More Math Games & Activities From Around the World, 2003, p. 146-147)

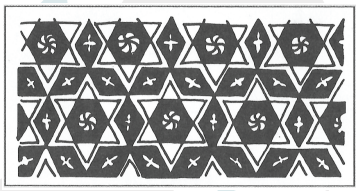

Fig. 1: A copy of a tiled wall from the Shāh-nāmeh (the Book of Kings)

This activity illustrates **how to use a circle to create some of the basic polygonal shapes** that can then be combined and arranged in an infinite variety of patterns, such as the one shown in the Shāh-nāmeh, the Book of Kings. (Fig. 1).

Instructions:

1. Open the compass to a radius of 4 cm. Draw a circle on the cardboard.
2. Make a pencil mark on the circumference of the circle. Using the same radius on the compass, place the compass point on the pencil mark and make an additional mark on the circumference of the circle. Place the compass point on that mark and make an additional mark on the circumference of the circle; repeat 3 more times (Fig. 2a).
3. Draw lines with the ruler connecting the 6 marks on the circle to make a regular hexagon (all sides are equal and all angles are congruent) (Fig. 2b).
4. Cut out the hexagon. Trace it on cardboard and cut out a second hexagon.
5. Cut the second hexagon in half to create two trapezoids (Fig. 2c).
6. See the diagram of the trapezoid (Fig. 2d). Measure from point A to B on one trapezoid. Make a pencil mark, E, so that BE equals AB. Draw a line with the ruler to connect point E to point A (Fig. 2d).
7. Cut along line AE to create equilateral triangle ABE and rhombus AECD.
8. Use the cardboard templates of the hexagon, triangle and rhombus to create additional shapes using the construction paper.
9. Create a copy of the pattern from the Shāh-nāmeh (the Book of Kings) (Fig. 1).

Extension: Students create their own repeating pattern using any or all of the four shapes.

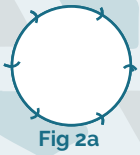

Fig 2a

Fig 2b

Fig 2c

Fig 2d

CURRICULUM CONNECTIONS

JK-SK

Demonstrating Literacy & Mathematics Behaviours and Problem Solving & Innovation

- OE13. >SE13.2, 13.3
- OE14. >SE14.3
- OE17. >SE17.1, 17.2,17.3
- OE18. >SE 18.1, 18.2, 18.
- OE20. >SE20.3
- OE21. >SE21.5, 21.6
- OE22. >SE22.1
- OE23. >SE23.2

Grade 1

Geometry & Spatial Sense

- identify common 2D shapes and sort and classify them by their attributes
- compose and decompose common 2D shapes
- describe the relative locations of objects using positional language

Patterning & Algebra

- identify, describe, extend, and create repeating patterns

Data Management & Probability

- collect and organize categorical primary data

Grade 2

Geometry & Spatial Sense

- identify 2D shapes and sort and classify them by their geometric properties
- compose and decompose 2D shapes
- describe and represent the relative locations of objects

Patterning & Algebra

- identify, describe, extend, and create repeating patterns

Grade 3

Geometry & Spatial Sense

- compare 2D shapes and sort them by their geometric properties
- describe relationships between 2D shapes
- identify and describe the locations and movements of shapes and objects

Patterning & Algebra

- describe, extend, and create a variety of numeric patterns and geometric patterns

Grade 4

Geometry & Spatial Sense

- identify quadrilaterals and classify them by their geometric properties
- identify and describe the location of an object and reflect 2D shapes

Patterning & Algebra

- describe, extend, and create a variety of geometric patterns, make predictions related to the patterns, and investigate repeating patterns involving reflections

Grade 5

Geometry & Spatial Sense

- identify and classify 2D shapes by side and angle properties
- identify and describe the location of an object and translate 2D shapes

Patterning & Algebra

- investigate repeating patterns involving translation

Grade 6

Geometry & Spatial Sense

- classify and construct polygons and angles
- rotate 2D shapes

Patterning & Algebra

- investigate repeating patterns involving rotations

REFERENCES

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